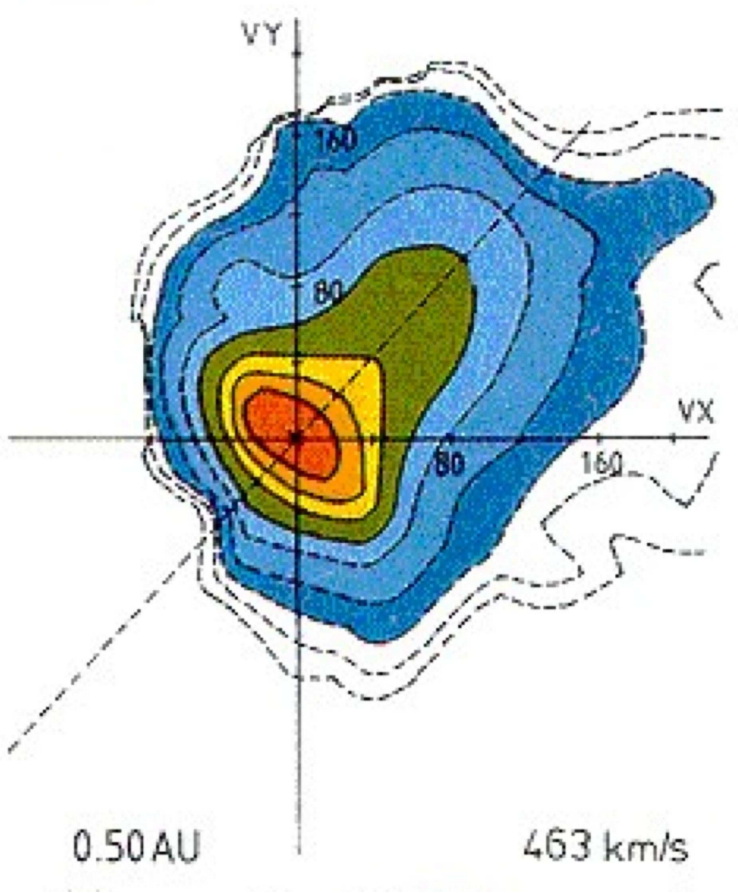
Phys 783 - Plasma Kinetic Theory
Assignment # 2
Due February 4, 2009

Reminders: Show your work! Include references on your submitted version. Write legibly!

1. **Sketching Distribution Functions**
   For each of the following scenarios, sketch the distribution function as stated.
   (a) In 1D, a warm plasma near the origin with a mean (bulk) speed of $u = u_0$. (This is called a warm "beam.") Sketch representative plots of x, v space and $f(v)$.
   (b) In 1D, a two-component plasma with hot ions and a warm ion beam moving at bulk speed $u = u_0$. Sketch representative plots of x, v space and $f(v)$.
   (c) In 1D, there are two interpenetrating warm beams with bulk speed $\pm u_0$ at a given location x_0. Sketch a representative plot of $f(x_0, v)$ as a function of v. (Three dimensional counterparts of such distribution functions are observed in the solar wind and are taken as evidence of magnetic reconnection.)

2. **Interpreting Distribution Functions**
   Interpret the ion distribution function shown below. The diagonal dashed line represents the direction of the local magnetic field. **Caution -** This is trickier than it looks! First identify how many populations there are, then discuss the properties of each.



   This data is taken from the solar wind [see Eckart Marsch, "Kinetic Physics of the Solar Corona and Solar Wind," Living Reviews, 2006]. If you can conclusively explain the physics behind it, you will be a very popular person!

3. **Plotting Distribution Functions**
   A distribution function is given as $f(x, v) = Ae^{-k|x|}e^{-b|v|}$, where A, k and b are constants. Plot contours of f in phase space. Plot $f(x_0, v)$ as a function of v for $x_0 = 4/k$.

4. **The Maxwell-Boltzmann Distribution Function**
   The Maxwell-Boltzmann distribution function in three dimensions is

$$f(\mathbf{v}) = Ce^{-m(\mathbf{v}-\mathbf{u})^2/2T},$$

   where C, m and T are independent of $\mathbf{v}$. We will use it a lot in the coming months.

   (a) Solve for C by properly normalizing f.

   (b) Show that the average velocity is $\mathbf{u}$.

   (c) Find the average kinetic energy $(1/2)mv^2$ and interpret the result.